Art. IX.—*Notes on the solubility of Gold-Silver Alloys in Cyanide of Potassium Solutions.*

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Some experiments were undertaken with the assistance of Messrs. Johnson and Osborne, students at the School, in order to determine the solubility of gold and silver alloys in potassium cyanide solutions.

Since pure gold never occurs in nature, and I have never met an alloy containing less than 60 per cent. of gold and 40 per cent. of silver, a series of alloys containing from 60 to 95 per cent. of gold was prepared for solution.

Gold cornets, which contain only a trace of silver, were taken and melted with the amount of pure silver required to make the given alloy. These were then rolled out and annealed, and strips were cut off and carefully weighed. The strips measured 1 inch in length and $\frac{1}{8}$ of an inch in width, and since they weighed about two grains, their thickness would be $\frac{1}{300}$ of an inch.

Small bulbs were blown on glass tubes, and a pin hole made in each bulb; into one of these each metallic strip was inserted and the whole were immersed in an inverted bell jar containing a ·25 per cent. solution of potassium cyanide, the liquid was kept several inches above the gold and was allowed to slowly drop through the stopper of the jar, thus ensuring a constant and fresh supply of cyanide for the gold. It was intended to have dissolved each of the strips completely, but it was found that after 597 hours' contact that the gold had commenced to separate out in fine flakes, and that several of the strips were eaten through, so it was decided to assay the undissolved alloy in order to find if its composition remained unaltered. The temperature of the laboratory during the time of experiment varied from 35°F. to 65°F.

Experiments were also tried on strips cut from the same alloys with the same solvent, only in this case the strips were placed in large test tubes and not disturbed. The action, as might be expected, was slower.

Next, the same series of alloys were used to test the solubility of gold in chlorine solutions.

A number of tubes were connected and partly filled with chlorine water—strips were placed in each tube and a slow stream of chlorine allowed to pass through them in a dark chamber for 90 hours. The strips were then washed with water, then with ammonia water until the chloride of silver which had encrusted the surface had dissolved; these were then dried and weighed.

A solution containing ·1 per cent. of chlorine was allowed to remain in contact with another series of strips for 304 hours, but the action was exceedingly slow.

It will be seen from the results of these experiments, that an alloy containing 95 per cent. of gold is dissolved more readily than pure gold or than alloys having a greater percentage of silver.

Further, that these alloys are not dissolved regularly and evenly, but that in some cases the action of the solvent is slower at first and more rapid after some time: since a crystalline surface was developed on those placed in the cyanide solution this may be due to rather a definite compound being more rapidly dissolved or the material between the crystals being attacked and thus allowing the crystals to stand out in relief.

It will also be seen that those alloys approaching the formula Au. Ag. are more evenly dissolved than those differing widely from that formula, the latter having a higher ratio of silver after partial solution, while the former are practically unchanged.

The circulating solution dissolved more gold in the same time than the fixed solutions.

In the case of the saturated chlorine solution the action was exceedingly rapid as compared with the cyanide, but even after 90 hours' contact only from 50 to 85 per cent. of the strips was dissolved.

In the case of the ·1 per cent. solution of chlorine the action was so slow that in 304 hours only from 4·85 to 15·89 per cent. of the metals was dissolved.

Since it requires 130 parts of potassium cyanide and 106·5 of chlorine to dissolve gold and keep it in solution, then a ·2 per cent. solution of chlorine should be almost equivalent to ·25 per cent. of potassium cyanide; these proportions closely approach the strength of solutions used in practice, *e.g.*, in modifications of Munktell process, such as used at Maldon and Cassilis, the amount of chlorine used being from 2 to 4 ozs. to the cubic foot of water, while the ordinary practice in cyanide operations is to use ·1 to ·4 per cent. solutions.

On testing certain roasted ores by both processes, it was found that by using a ·25 per cent. solution of cyanide of potassium and a ·2 per cent. solution of chlorine, that almost an equal quantity of gold was dissolved in 72 hours, the slight difference being in favour of the chlorine. With badly roasted ores, such as have been roasted at a low temperature, also those containing large quantities of arseniates, it is not possible to dissolve a high proportion of the gold present either with excess of a saturated solution of chlorine or with potassium cyanide solutions, but with ores which have been properly roasted, and in which the gold is fine, it will be found that an ordinary solution of cyanide will act as well as chlorine, and with the additional advantage that the silver alloyed with the gold will be dissolved and may be recovered also.

Table showing the Solubility of Gold-Silver Alloys.

Solvent—·25 per cent. Potassium Cyanide Solution—Circulating.

Number of hours in solution				65	123	197	367	597	Composition of Alloy after 597 hours.	
mposition of Alloy.			Weight taken in Grains.	Weight after 65 hrs.	Weight after 123 hrs.	Weight after 197 hrs.	Weight after 367 hrs.	Weight after 597 hrs.		
o.	Gold.	Silver.							Gold.	Silver.
	100	trace	1·760	1·682	1·600	1·505	1·144	·808	100	—
	95	5	2·094	2·018	1·872	1·640	·940	·610	90·9	9·1
	90	10	1·770	1·705	1·584	1·490	1·297	1·150	86·2	13·8
	80	20	1·820	1·740	1·624	1·470	1·087	·995	75·4	24·6
	70	30	2·050	1·840	1·762	1·612	1·104	·774	69·8	30·2
	60	40	2·146	2·030	1·832	1·686	1·150	·794	60	40

Loss of Weight expressed in Percentage.

1	100	trace	100	4·43	9·09	14·49	35·00	54·1
2	95	5	100	3·63	10·60	21·68	50·14	70·9
3	90	10	100	3·67	10·51	15·82	26·73	35·0
4	80	20	100	4·39	10·77	19·23	40·27	47·5
5	70	30	100	10·20	14·05	21·36	46·01	62·2
6	60	40	100	5·45	14·63	21·71	46·41	63

Solvent—·25 per cent. Potassium Cyanide Solution—Stationary.

Number of hours in solution				48	84	48	84
No.	Gold.	Silver.	Weight taken.			Percentage dissolved.	
1	100		2·080	2·044	1·985	1·73	4·57
2	95	5	2·006	1·926	1·836	3·99	8·47
3	90	10	2·034	1·966	1·889	3·34	7·12
4	80	20	2·049	1·992	1·936	2·78	5·51
5	70	30	2·016	1·936	1·879	3·91	6·78
6	60	40	2·047	1·963	1·822	3·61	10·99

It would thus appear that the most effective cyanide solution (proved by Maclaurin to be a ·25 %) is not so rapid in action as the chlorine solution usually worked with in practice, but it must be borne in mind that the chlorine solution (·4 %) is twice as strong as the cyanide solutions generally used. I should also have mentioned that during the progress of the experiments it was noticed that wherever the strips touched the containing vessels they were not attacked so much at those points. This will account for small irregularites observed.

Table Showing the Solubility of Gold-Silver Alloys.

Solvent—Saturated Solution of Chlorine Water.

	Composition.					
No.	Gold.	Silver.	Weight taken.	Weight after 90 hrs.	Loss.	Per. cent. dissolved.
1	100	trace	2·014	·994	1·020	50·64
2	95	5	2·014	·300	1·714	85·10
3	90	10	2·040	·630	1·410	69·11
4	80	20	2·023	·438	1·585	78·34
5	70	30	2·036	·620	1·416	69·05
6	60	40	2·038	·882	1·156	59·66

Each strip of gold was immersed in 50 cc. of water, through which a continuous stream of chlorine was allowed to pass.

SOLVENT—DILUTE SOLUTION—CHLORINE WATER.

No.	Composition. Gold.	Silver.	Weight taken.	Weight after 184 hrs.	Weight after 304 hrs.	Per cent. loss of weight 184 hrs.	Per cent. loss of weight after 304 hrs.
1	100	trace	1·856	1·811	1·766	2·42	4·85
2	95	5	2·000	1·874	1·840	6·30	8·00
3	90	10	2·060	1·885	1·831	8·05	11·11
4	80	20	1·822	1·760	1·721	3·40	5·54
5	70	30	1·560	1·527	1·468	1·47	5·90
6	60	40	1·560	1·437	1·312	7·94	15·89

Solution was made so that it contained ·1 % of chlorine. Non-circulating.

The experiment with a 95 % alloy, 95 Au., and 5 Ag., was as follows:—

2·011 grains of gold – ·4 % chlorine solution.

Weight after 96 hrs. in circulating solution } 1·554 grains.

Loss of weight: 96 hrs. = ·457 grains.

And % loss of weight is 22·7.